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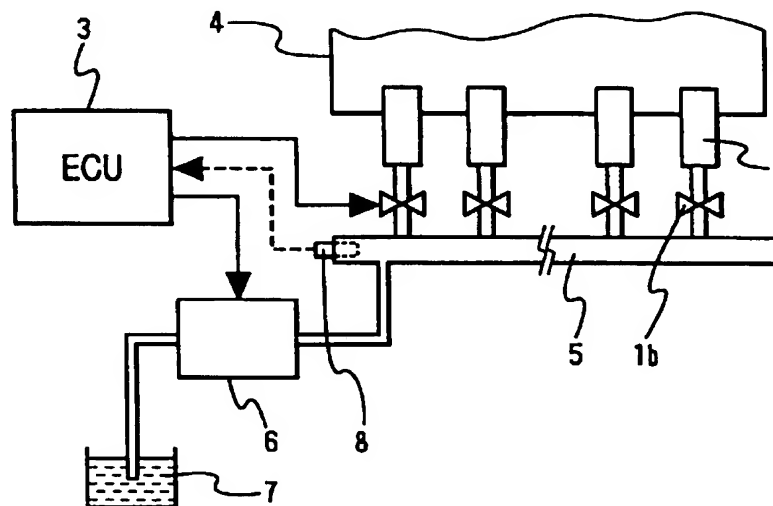
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(54) Fuel injection system having a plurality of injectors

(57) Deviation in fuel injection quantity among injectors (1) is corrected by a simple structure. Injector 1 is provided with data memory (2, 2A) which memorizes discrimination data for injection characteristic of each of the injectors (1) to discriminate the injection characteristic of individual injectors (1). As a result, control signals

supplied to the injector 1 are corrected to reduce deviation in the fuel injection quantity among the injectors (1) without much increasing production cost and to save work of allocating each of the injectors (1) to a specified cylinder.

FIG. 2



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Description

[0001] The present invention relates to a fuel injection system having a plurality of injectors.

[0002] A common-rail-type fuel injection system is well-known as one of diesel engine fuel injection systems. In the common-rail type fuel injection system, a suitable amount of high-pressure fuel is supplied by a variable-capacity high-pressure pump to a common-rail which connects each of diesel engine cylinders, so that the fuel pressure in the common-rail can be controlled at a certain value. The high pressure fuel in the common-rail is supplied to each injector to inject the fuel into a combustion chamber of one of cylinders at a suitable injection timing. Each injector opens or closes a valve thereof in response to a control signal of an electronic control unit to start or stop injection timely. The electronic control unit calculates valve opening period from command injection timing of the injector and command injection quantity thereof and sends each injector the control signal correspondingly to valve-opening period.

[0003] In the injector of the common-rail-type fuel injection system, accuracy of the metered injection quantity is required to be no more than 1 mm³ at the supplied fuel pressure of 100 MPa or higher. Various efforts of engineering and production control have been made to reduce variation in injection characteristics of the injectors.

[0004] In order to control the variation within a required level, investment in production facilities and adjusting work of injection quantity in the production process necessarily increase, thereby resulting in significant increase in the production cost of the injectors.

[0005] It can be considered that individual characteristics and the correction data of injectors that are used with an electronic control unit of fuel injection system are originally stored in the same electronic control unit in order to eliminate variation in injection quantity among a plurality of injectors. This necessitates a work to combine individual injectors and a specific electronic control unit suitable to each other. In other words, it is necessary to fix each injector to a designated cylinder of an engine having a multiple cylinders, and assembling work of injectors becomes troublesome.

[0006] The present invention has been made in view of the above situation. Therefore, it is an object of the invention to provide injectors and fuel injection system which can operate with individual injection characteristics of respective injectors without combining each of the injectors with specific cylinders or a specific control unit.

[0007] According to the invention claimed in claim 1, a discrimination data memory storing predetermined discrimination data of respective injection characteristics is provided to correct the control signal on the basis of the discrimination data.

[0008] Because the injection characteristics of individual injector are discriminated by the discrimination data, an injection control suitable to such injection characteristics is ensured. Because the data memory is installed into the injectors, it is not necessary to combine each injector with one control unit in a set or to designate each injector to a specific cylinder of an engine.

[0009] The discrimination data memory can be a resistor whose resistance is the discrimination data, or a tag on which bar-codes are formed as the discrimination data.

[0010] According to the invention claimed in claim 4, the injection system including the injector according to any one of claims 1-3 and a control means which calculates a valve opening period on the basis of command injection timing of the injector and command injection quantity and outputs the control signal in correspondence to the valve opening period. The control means includes a correction parameter map in which correction parameters respectively correspond to the discrimination data, and one of the correction parameters is selected from data of the discrimination data memory to correct the valve opening period that is calculated on the basis of the command injection time and the command injection quantity.

[0011] Because fuel injection characteristics of respective injectors are discriminated to select a suitable correction parameter, the control means can specify each injector easily so that each injector can be controlled accurately. Since injector has a data memory, it is not necessary to combine each injector with one control unit in a set or to allocate each injector to a specific cylinder of an engine.

[0012] According to the invention claimed in claim 5, the data memory comprises resistors; and the control means comprises resistance-measuring means for measuring the resistance thereof as the discrimination data.

[0013] Because the control means can obtain the discrimination signal as resistance, it is not necessary to rewrite the correction data in the control means when an injector is replaced for repair, so that serviceability can be improved.

[0014] According to the invention claimed in claim 5, the parameter map has a plurality of correction parameters that respectively correspond to the discrimination data.

[0015] The plurality of correction parameters ensures that each injector can be corrected accurately according to its injection characteristics. A plurality of correction parameters which correspond to each discrimination data prevents the memory from becoming complicated.

[0016] According to the invention claimed in claim 7, each of the correction parameters includes an offset value of valve opening period at a basic pressure of supplied fuel. The control means includes a valve-opening-period adjusting coefficient map in which adjusting coefficients correspond to supplied fuel pressure, and the offset value of an actual valve opening period is obtained by multiplying one of the valve-opening-period-adjusting coefficients by the offset

value of the basic pressure.

[0017] Because an offset value of the valve opening period related to the supplied fuel pressure can be obtained, the valve timing can be corrected accurately.

[0018] According to the invention claimed in claim 8, the correction parameters include a low-side offset value of valve-opening period at a lower side basic pressure of supplied fuel and a high-side offset value of valve-opening period at a higher side basic pressure of the supplied fuel. The control means is structured so that the an offset value at a lower actual fuel pressure is obtained by multiplying the valve-opening-period-adjusting coefficients by the low-side offset value and the offset value of valve opening period at a higher side actual pressure of the supplied fuel is obtained by multiplying the valve-opening-period-adjusting coefficients that is read from the valve-opening-period adjusting coefficients map by the high-side offset value.

[0019] Since the offset value of the valve-opening period at the basic pressure is set separately to the low pressure side and the high pressure side, the valve-opening-period-adjusting coefficient can be set at a high correlation.

[0020] According to the invention claimed in claim 9, the correction parameters include an offset value of valve opening period, and the offset value of valve timing is obtained by multiplying the valve-timing-adjusting coefficients by the offset value of valve opening period.

[0021] The delay of the valve timing after receiving the control signal causes an error of the valve opening period. Accordingly, the offset value of the valve timing is given in proportion to the offset value of the valve opening period so that the delay of the valve timing can be reduced easily.

[0022] According to the invention claimed in claim 10, the control means includes a valve-timing-adjusting-coefficient map in which valve-timing-adjusting-coefficient correspond to supplied fuel pressures, and an offset value of the valve timing is obtained by multiplying the valve-timing-adjusting coefficients that is read from the valve-timing-adjusting-coefficients map by the offset value of valve-opening period at the basic pressure.

[0023] The offset value of the valve timing related to the supplied fuel pressure can be obtained, so that the valve timing can be corrected accurately.

[0024] According to the invention claimed in claim 11, the correction parameters include the same kind of correction parameters which are respectively set for a plurality of command-injection-quantity ranges.

[0025] Because more or less injection quantity or longer or shorter valve-opening period of the injector differentiates factors affecting the fuel flow rate of the injector, the correction parameters are set within a range of command injection quantity to accurately correct the valve-opening period.

[0026] According to the invention claimed in claim 12, the correction parameters include an offset value of valve opening period when the command injection quantity is smaller basic injection quantity and an offset value of valve-opening period when the command injection quantity is larger basic injection quantity, and the valve-opening period is set by linear interpolation of valve-opening periods that are respectively corrected at the two basic injection quantity levels.

[0027] Therefore, the offset value gradually increases or decreases relative to the command injection quantity. Therefore, even if increasing or decreasing ratio to the command injection quantity varies with injectors, the variation can be offset.

Fig. 1 is a cross-sectional view illustrating an injector according to a first embodiment of the invention.

Fig. 2 is a schematic diagram illustrating the entire fuel injection system according to the first embodiment.

Fig. 3 is a schematic diagram illustrating a main portion of the fuel injection system according to the first embodiment.

Fig. 4 is a table showing a correction parameter map of the fuel injection system according to the first embodiment.

Fig. 5 is a table of allocation of the resistance of resistors used in the fuel injection system according to first embodiment.

Fig. 6 is a table showing a valve-opening-period adjusting-coefficient map of the fuel injection system according to the first embodiment.

Fig. 7 is a first flow diagram showing control operation of an electronic control unit of the fuel injection system according to the first embodiment.

Fig. 8 is a second flow diagram showing control operation of the electronic control unit of the fuel injection system according to the first embodiment of the invention.

Fig. 9 is a third flow diagram showing control operation of the electronic control unit of the fuel injection system according to the first embodiment.

Fig. 10 is a fourth flow diagram showing control operation of the electronic control unit of the fuel injection system according to the first embodiment of the invention.

Fig. 11 is a first graph showing operation of the electronic control unit of the injectors and the fuel injection system according to the first embodiment.

Fig. 12 is a second graph showing operation of the electronic control unit of the injectors and the fuel injection sys-

tem according to the first embodiment.

Fig. 13 is a schematic diagram illustrating a main portion of a fuel injection system according to a second embodiment of the invention.

Fig. 14 is a table showing a correction parameter map of the fuel injection system according to the second embodiment.

Fig. 15 is a first flow diagram showing control operation of an electronic control unit of the fuel injection system according to the second embodiment of the invention.

Fig. 16 is a second flow diagram showing control operation of an electronic control unit of the fuel injection system according to the second embodiment.

Fig. 17 is a first graph showing operation of the injector and the electronic control unit according to the second embodiment.

Fig. 18 is a second graph showing operation of the injector and the electronic control unit according to the second embodiment.

Fig. 19 is a graph showing a variation in correction of injection pulse duration in the fuel injection system according to the second embodiment.

Fig. 20 is a main portion of a fuel injection system according to a third embodiment of the invention.

Fig. 21 is a diagram showing a correction parameter map of the fuel injection system according to the third embodiment.

Fig. 22 is a first flow diagram showing control operation of the fuel injection system according to the third embodiment.

Fig. 23 is a second flow diagram showing control operation of the electronic control unit of the fuel injection system according to the third embodiment.

Fig. 24 is a third flow diagram showing control operation of the electronic control unit of the fuel injection system according to the third embodiment.

Fig. 25 is a first graph showing control operation of an injector and the fuel injection system according to the third embodiment.

Fig. 26 is a second graph showing control operation of the injector and the fuel injection system according to the third embodiment.

Fig. 27 is a third graph showing control operation of the injector and the fuel injection system according to the third embodiment.

Fig. 28 is a time chart showing operation of the injector and the fuel injection system according to the fourth embodiment.

Fig. 29 is a main portion of the fuel injection system according to the fourth embodiment.

Fig. 30 is a table showing a correction parameter map of the fuel injection system according to the fourth embodiment.

Fig. 31 is a table showing a basic valve-opening-delay-time map of the fuel injection system according to the invention.

Fig. 32 is a table showing a valve-opening-delay-adjusting coefficient map of the fuel injection system according to the fourth embodiment.

Fig. 33 is a first flow diagram showing control operation of an electronic control unit of the fuel injection system according to the fourth embodiment.

Fig. 34 is a second flow diagram showing control operation of the electronic control unit of the fuel injection system according to the fourth embodiment.

Fig. 35 is a third flow diagram showing control operation of the electronic control unit of the fuel injection system according to the fourth embodiment.

Fig. 36 is a fourth flow diagram showing control operation of the electronic control unit of the fuel injection system according to the fourth embodiment.

Fig. 37 is a graph showing operation of the injector and the electronic control unit of the fuel injection system according to the fourth embodiment.

Fig. 38 is a time chart showing operation of the injector and the electronic control unit of the fuel injection system according to the fourth embodiment.

Fig. 39 is a side view illustrating a fuel injector according to a fifth embodiment of the invention.

Fig. 40 is a schematic diagram illustrating a process of taking bar code data of an injector into the electronic control unit of the fuel injection system according to the fifth embodiment.

Fig. 41 is a schematic diagram illustrating another process of taking bar code data of an injector into the electronic control unit of the fuel injection system according to the fifth embodiment of the invention.

(First Embodiment)

[0028] An injector and a fuel injection system according to a first embodiment of the invention is described below with reference to Figs. 1-12. In a system diagram shown in Fig. 2, engine 4 is provided with a plurality of injectors 1 fixed to respective cylinders. The plurality of injectors 1 are connected to common-rail 5. Each injector 1 has electromagnetic valve 1b as shown in Fig. 1 and opens or closes valve 1b in response to a control signal and supplies one of the engine cylinders with fuel from common-rail 5. In this embodiment, engine 4 has four cylinders.

[0029] Common-rail 5 is connected to variable-capacity high-pressure pump 6 which continuously accumulates fuel in common-rail 5 at a certain high pressure. Variable-capacity high-pressure pump 6 pressurizes low-pressure fuel which is pumped up from fuel tank 7 to a certain high pressure.

[0030] The fuel injection system includes electronic control unit (ECU) 3 and variable-capacity high-pressure pump 6. Electronic control unit 3 is comprised of a common hard ware having CPU and the like and outputs control signals to control injectors 1. Electronic control unit 3 receives engine condition signals from engine-rotation-speed sensor, cylinder-discrimination sensor, and etc., which are not shown. A pressure sensor 8 is disposed in common-rail 5 to detect common-rail pressure, which is inputted into electronic control unit 3. Electronic control unit 3 determines command injection timing and command injection quantity according to the above stated input data, provides valve opening timing and valve opening period, and sends control signals to the respective injectors 1.

[0031] As shown in Fig. 1, injector 1 is comprised of nozzle 1a, electromagnetic valve 1b, and connector 1c. Connector 1c, which is one of the features of this invention, is fixed to the upper portion of electromagnetic valve 1b.

[0032] Nozzle 1a has nozzle holder 103, needle valve 106, piston 108, spring 109, control chamber 110, bar filter 112, and injection chamber 114.

[0033] Nozzle holder 103 has fuel injection hole 102 formed at the edge thereof, inlet portion 104 extending obliquely upward, and return portion 105. Inlet portion 104 is connected to common-rail 5 (as shown in Fig. 2). Return portion 105 has hollow screw 129 to be connected to a return pipe which is connected to fuel tank 7.

[0034] Needle valve 106 is slidably disposed in nozzle hole 103 to open or close fuel injection hole 102. Piston 108 is slidably disposed in guide hole 107 formed in nozzle holder 103 at the upper end of needle valve 106. Spring 109 is disposed around piston 108 to bias needle valve 106 downward via piston 108 to normally close the valve. Control chamber 110 is formed at rear end surface 108a of piston 108, which functions as a chamber wall movable up and down. Inlet fluid passage 111, which has inlet port 111a at the edge of inlet portion 104, conducts high-pressure fuel of common-rail 5. Bar filter 112 is disposed just downstream from inlet port 111a to remove foreign particles thereby. Inlet fluid passage 111 branches out into two passages at the base of inlet portion 104, one passage 113 of which downwards extends to fuel injection hole 102 of nozzle body 101.

[0035] Injection chamber 114 is formed at a portion of passage 113 to surround tapered waist portion 106a of needle valve 106, so that needle valve 106 is always biased to open by the internal pressure thereof.

[0036] The other branch passage 115, which upwardly extends, connects with control chamber 110 through aperture 116. When the internal pressure of control chamber 110 is so high that resultant press-down force of needle valve 106 and the spring force of spring 109 becomes larger than push-up force of injection chamber 114, needle valve 106 moves down. On the other hand, when the internal pressure of control chamber 110 becomes so low that the press-down force becomes smaller than the push-up force, needle valve 106 moves up.

[0037] Control chamber 110 connects, through passage 117 formed at upper portion thereof and electromagnetic valve 1b, with return pipe 118 which opens to the bottom of hollow screw hole 119 formed at return portion 105. A portion of the fuel supplied from inlet portion 104 is returned to fuel tank 7 through a return passage formed by passage 115, aperture 116, control chamber 110, passage 117, electromagnetic valve 1b, return pipe 118 and hollow screw 129.

[0038] Electromagnetic valve 1b is comprised of valve portion 120, push rod 123, spring chamber 124, armature chamber 126, armature 127, and solenoid 128.

[0039] Valve portion 120 of electromagnetic valve 1b is comprised of seat portion 121 formed at upper opening of passage 117 and ball 122 as its valve body. Ball 122 is always biased to close through push rod 123 by spring 125 which is accommodated in spring chamber 124 which connects with return pipe 118. Disc-like armature 127 is coaxially inserted into armature chamber 126, which always connects with return pipe 118, around upper portion of push rod 123.

[0040] Solenoid 128 is disposed above armature 127 to face the same. When electronic control unit 3 sends a control signal, solenoid 128 is excited to pull armature 127 so that push rod 123 can be moved upward. Consequently, valve portion 120 opens to lower the pressure of control chamber 110, and needle valve 106 is lifted to inject fuel. When solenoid 128 is not excited, valve portion 120 closes to increase the pressure of control chamber, so that needle valve 106 can be seated to stop the fuel injection.

[0041] Connector 1c has two terminals 130 and 132 which are connected to electronic control unit 3 through a cable (not shown). First terminal 130 conducts the control signals from electronic control unit 3 to solenoid 128 via drive line 131. Second terminal 132 is connected to correction resistor 2 which is built in connector 1c as a data memory. Cor-

rection resistor 2 is selected so that it can correspond to the injection characteristic of injector 1, which is detected by an inspection beforehand.

[0042] As shown in Fig. 3, electronic control unit 3 has pull-up electric power source 32 and pull-up resistor 33, which form voltage detection circuit 3a as a means for detecting the resistance. Pull-up electric power source 32 provides constant voltage V_c , which is applied to correction resistor 2 through pull-up resistor 33. Voltage V_i appearing across correction resistor 2 is inputted to A-D converter 34. Voltage V_i is a portion of constant voltage V_c divided by pull-up resistor 33 and correction resistor 2 and is expressed as expression (1), wherein the resistance of pull-up resistor is R_1 , resistance of correction resistor 2 is R_2 :

$$V_i = R_2 \cdot V_c / (R_1 + R_2) \quad (1)$$

[0043] The detected resistance signal of correction resistor 2, which is voltage V_i , is converted by A-D converter 34 and is inputted into CPU 31. CPU 31 classifies the detected voltage into twenty five voltage grades. A correction parameter for each injector 1, which has individual injection characteristics corresponding to the respective voltage levels, is selected from correction parameter map 35.

[0044] Correction parameter map 35 is stored in ROM 310 together with the control program of injectors 1 and variable capacity high pressure pump 6, as illustrated in Fig. 4. Each of the numerals 1-25 in the table indicates one of voltage grades. A larger numeral indicates a higher voltage grade. Correction parameter map 35 is a two-dimension map in which one voltage grade of voltage V_i corresponds to a pair of correction parameters t_{qcmh} and t_{qcml} . Correction parameters t_{qcmh} and t_{qcml} are used for offset-correction of an injection pulse duration or valve opening period that is calculated from a command injection quantity. One correction parameter t_{qcmh} is a high-side correction value to be used when the common-rail pressure is higher than a certain pressure, and the other correction parameter t_{qcml} is a low-side correction value to be used when the common-rail pressure is lower than the certain pressure.

[0045] CPU 31 selects a pair of correction parameters t_{qcmh} and t_{qcml} from correction parameter map 35 according to the voltage grade which voltage V_i corresponds to. For example, if voltage V_i corresponds to voltage grade "7" in Fig. 4, high-side correction value t_{qcmh} is $-20 \mu s$, and low-side correction value t_{qcml} is $+25 \mu s$. The resistance of correction resistor 2, which fixes voltage V_i , should be allocated taking resistance variation of resistor 2 due to temperature change and precision of A-D converter 34 into consideration. Fig. 5 shows a sample of allocation of the resistances, wherein voltage V_c is 5.0 V and the resistance of pull-up resistor 33 is 619Ω . The difference between two adjacent resistances becomes larger as the resistance value increases, which is in accordance with expression (1). Thus, one voltage V_i provided by one correction resistor 2 may not be too close to another voltage V_i provided by another correction resistor 2, so that correction parameters t_{qcmh} and t_{qcml} can be correctly selected. Each of the voltage grades are set so that the design-target value of voltage V_i is at the middle of the voltage grade. In order to minimize problems if resistance of different correction resistance adjacent to a proper correction resistance is erroneously selected, they are allocated so that resistors correction values are in order of the magnitude, as shown in Fig. 4.

[0046] Electronic control unit 3 also has valve-opening-period adjusting-coefficient map 36. Adjusting-coefficients map 36 is stored together with correction parameter map 35. Fig. 6 shows adjusting-coefficient map 36 in which a pair of correction parameters t_{mtqpch} and t_{mtqpcl} corresponds to one common-rail pressure level. The correction parameter adjusts the offset value of the injection pulse duration according to the common-rail pressure and is used to correct a basic pulse duration together with high-side correction parameter t_{qcmh} and low-side correction parameter t_{qcml} . Low-side correction parameter t_{mtqpch} becomes 0 at lower pressure levels and High-side correction parameter t_{mtqpcl} becomes 0 at higher pressure levels.

[0047] In Fig. 7, an initial routine is executed after turning on the ignition key switch IG. After initializing a RAM and other parts in step S101, voltage V_i of each correction resistor 2 installed in connectors 1c of injectors 1 is read in step S102. In step S103, high-side correction parameters $t_{qcmh}(j)$ ($j=0, 1, 2, 3$: cylinder's number) and low-side pressure correction parameters $t_{qcml}(j)$ for respective injectors 1 are picked up from correction parameter map 35. High-side correction parameters $t_{qcmh}(j)$ and low-side correction parameters $t_{qcml}(j)$ are stored in the above RAM to correspond to the cylinder number. If voltage V_i is out of all the voltage grades in step S103, in other words, if voltage V_i is lower than the lowest grade or higher than the highest grade, it is determined that the cable connecting correction resistor 2 and electronic control unit 3 is short-circuited or broken. Then, high-side correction parameters $t_{qcmh}(j)$ and low-side correction parameters $t_{qcml}(j)$ are set $0 \mu s$.

[0048] Those parameters are selected only at the initial routine to avoid errors in measuring voltages V_i due to electrical noise and are maintained until the ignition key switch is turned on again.

[0049] In order to avoid erroneous storing in the RAM, upper-and-lower-limit check routine is executed as shown in Fig. 8. At step S201, whether each of high-side correction parameter $t_{qcmh}(j)$ and low-side of correction parameter $t_{qcml}(j)$ is adequate value to be selected from correction parameter map 35 or not is examined. In other words, whether high-side correction parameter $t_{qcmh}(j)$ is or is not between the maximum value EP2H (e.g. $+40 \mu s$ in Fig. 4) and the minimum value EN2H (e.g. $-40 \mu s$ in Fig. 4) is examined, and whether low-side correction parameter $t_{qcml}(j)$ is or is

not between the maximum value EP2L (e.g. +50 μ s in Fig. 4) and the minimum value EN2L (e.g. -50 μ s in Fig. 4) is examined. If the result is YES, then it is determined that no error exists in the RAM, and the routine is ended.

[0050] If the result of step S201 is NO, it is determined that there is some error in the RAM. Then, step S202 follows, where high-side correction parameter tqcmh (j) and low-side correction parameter tqcml (j) are set to 0 so that no correction can be made. Then, the routine is ended.

[0051] As shown in Fig. 9, 8-ms-routine is executed every 8 milli-second. In this routine, pressure correction parameters tqcm (j) for correcting basic pulse duration for respective cylinders are calculated. At step S301, the common-rail pressure is read. At step S302, valve-opening-period adjusting-coefficients t_mtpch, t_mtpcl which correspond to a common rail pressure are selected from adjusting-coefficient map 36. If such a common-rail pressure falls between adjacent stored pressure grades in the map, they are calculated by linear interpolation of adjusting coefficient t_mtpch, t_mtpcl which correspond to the adjacent common-rail pressure grades. Then, pressure correction parameter tqcm (j) is calculated by the following expression (2), high-side correction parameter tqcmh (j), and low-side correction parameter tqcml (j):

$$tqcm(j) = t_mtpch \times tqcmh(j) + t_mtpcl \times tqcml(j) \quad (2)$$

and the routine is ended.

[0052] In the meantime, the intermediate area between higher pressure grade and lower pressure grade (e.g. area between 48 MPa and 64 MPa in Fig. 6) is calculated by linear interpolation of pressure correction parameter tqcm (j) at the highest side of the low-side correction grade and pressure correction parameter tqcm (j) at the lowest side of the high-side correction grade.

[0053] Fig. 10 is an angular synchronism routine, which is executed every 180° CA (crank angle) in case of a four-cylinder engine. At step S401, vehicle condition parameters such as throttle valve's open-angle Ac and vehicle speed are detected. At step S402, command injection quantity is calculated from the vehicle condition parameters, and command injection timing is calculated at step S403. At the next step S404, basic pulse duration tqbase that is the injector's turning-on period is calculated from the above command injection quantity. Then, step S405 follows, where one of the cylinder number is read. At step S406, the pressure correction parameter tqcm (j) that corresponds to the same cylinder number is read. At step S407, the basic pulse duration tqbase, which is read at step S404, is added to pressure correction parameter tqcm (j), which is read at step S408, thereby obtaining corrected injection pulse duration tqfin. At step S408, corrected injection pulse duration tqfin is set in a drive-pulse-control register. The drive pulses are supplied to injectors so that electromagnetic valve 1b is energized during the corrected injection pulse duration.

[0054] In the above described flow diagram, adjusting coefficient t_mtpch becomes 0 when the common-rail pressure is low, and adjusting coefficient t_mtpcl becomes 0 when the common-rail pressure is high as shown in adjusting coefficient map 36 in Fig. 6. Therefore, when the common-rail pressure is high (e.g. 135 MPa), pressure correction parameter tqcm (j) is the product of high-side correction parameter tqcmh (j) and adjusting coefficient t_mtpch. On the other hand, when the common-rail pressure is low (e.g. 48 MPa), pressure correction parameter tqcm (j) is the product of low-side correction parameter tqcml (j) and adjusting coefficient t_mtpcl.

[0055] The high-side correction parameter tqcmh (j) and the low-side correction parameter tqcml (j) are given to each injector to correspond to its injection characteristic. However, adjusting coefficient map 36 is the same if the fuel injection system including injectors 1 is the same. The fuel injection system according to the preferred embodiment of the invention, the pressure correction parameter tqcm (j) for the higher pressure grade (tqcmh (j)) is set separately from that for the lower pressure grade (tqcml (j)), whereby the pressure correction parameter tqcm (j) can corresponds to the individual injector accurately.

[0056] Fig. 11 is a graph having correction values T corresponding to various basic pressure grades on the horizontal axis and corrected value Ti of other pressure grades on the vertical axis, in which correction parameters (μ s) corresponding to the basic pulse duration is calculated so that an adequate command injection quantity for each of a number of sampled injectors 1 can be obtained under each of various common-rail pressure grades. Then, a coefficient of correlation between correction values T and corrected value Ti is calculated to provide a correlation function ($T_i = k_i \times T$). As the coefficient of correlation becomes closer to 1, coefficient k_i becomes more appropriate to adjusting coefficient t_mtpch or t_mtpcl. In other words, each injector 1 can be given an appropriate pressure correction parameter tqcm (j).

[0057] Fig. 12 is a graph showing correlation coefficients relative to the common-rail pressure. If the basic pressure is set at a higher pressure side, the correlation coefficient becomes lower as the pressure becomes lower. The pressure correction parameters tqcm (j) at higher pressure sides (high side pressure) are calculated from the high-side correction parameter tqcmh (j), and the pressure correction parameters tqcm (j) at lower sides are calculated from the low-side correction parameter tqcml (j). Therefore, the fuel injection period of each injector 1 can be corrected accurately.

[0058] A correction resistor is installed in connector 1c of each injector 1 so that injection pulse duration can be corrected to correspond to the injection characteristic. Therefore, it is not necessary to combine each injector 1 with a tai-

lor-made electronic control unit 3, or to allocate each injector 1 to a specific cylinder of an engine.

[0059] Because injectors 1 are discriminated from each other by the resistance of the correction resistors, electronic control unit 3 can get discrimination data easily if it supplies the resistors with electric current. If injector 1 is replaced by another in repair or the like, electronic control unit 3 can select a correction parameter according to measured voltage across the resistor when it is initialized. Therefore, it is not necessary to rewrite ROM 310 each time injector 1 is replaced. This improves serviceability.

[0060] Correction parameter map 35 is a multiple dimension map for voltage V_i , in which a plurality of injection characteristic data (correction parameters) are available for each injector 1 without providing a complicated structure having a plurality of correction resistors 2 and voltage measurement circuits 3a for each injector 1.

(Second Embodiment)

[0061] A fuel injection system according to a second embodiment of the invention is described with reference to Figs. 13-19. Electronic control unit 3A is different from the first embodiment. Electronic control unit 3A is substantially the same in structure as the first embodiment except for correction parameter map 35A.

[0062] Correction parameter map 35A, as shown in Fig. 14, has two correction parameters TQC1 (j) and TQC2 (j) for each voltage level V_i . The correction parameter is provided by offset-correction of the injection pulse duration that corresponds to the valve opening period calculated from the command injection quantity. One is the first correction parameter for a large quantity side basic injection quantity (e.g. 50 mm³/st), and the other is the second correction parameter for a small quantity side basic injection quantity (e.g. 5 mm³/st).

[0063] Figs. 15 and 16 illustrate a flow diagram of electronic control unit 3A controlling injectors 1.

[0064] In Fig. 15, the initial routine is executed after IG key is turned on. In step S501, a RAM and other components are initialized. Thereafter, at step S502, terminal voltages V_i of respective built-in resistors 2 are read. At step S503, first correction parameter TQC1 (j) and second correction parameter TQC2 (j) for each cylinder (j = 0, 1, 2, 3) are obtained from correction parameter map 35A. First correction parameter TQC1 (j) and second correction parameter TQC2 (j) for each cylinder is stored in the RAM. If voltage V_i is out of any one of the voltage grades at step S503, or if the pressure is lower than the pressure corresponding to the lowest voltage grade or higher than the pressure corresponding to the highest voltage grade, it is considered that a cable connecting injector 1 and electronic control unit 3 is short-circuited or cut. Consequently, first correction parameter TQC1 (j) and second correction parameter TQC2 (j) are set 0 μ s to stop the correction.

[0065] Correction parameters TQC1 (j) and TQC2 (j) are selected only in the initial routine and will not be renewed until the IG key is turned on again. For example, an upper-and-lower-limit check routine is executed every 64 ms to prevent an erroneous storing in the RAM as described in the first embodiment. If it is considered as the erroneous storing of the RAM, first correction parameter TQC1 (j) and second correction parameter TQC2 (j) are set to 0.

[0066] Fig. 16 shows an angular synchronism routine, which is executed every 180° CA (crank angle) in case of a four-cylinder engine. At step S601, operation parameters such as a throttle open angle A_c , a vehicle speed and the like are read. Then, command injection quantity is calculated on the basis of the above operation parameters at step S602, and command injection timing is calculated at step S603. In step S604, basic pulse duration t_{qbase} is calculated on the basis of the above data including the command injection quantity to proceed to step S605. A number of the cylinder to inject fuel is read at step S605, and the correction parameter corresponding to the calculated injection quantity is calculated at step S606. The correction parameters TQC (j) are calculated as follows. Firstly, correction parameters TQC1 (j) and TQC2 (j) that correspond to the above cylinder number are read. Then, as shown in Fig. 17, the correction parameter TQC (j) is calculated by the linear interpolation on the basis of the first correction parameter TQC1 (j) of the large-quantity-side first basic injection quantity (50 mm³/st) and second correction parameter TQC2 (j) of the small-quantity-side second basic injection quantity (5 mm³/st). At step S607, correction parameter TQC (j) is added to basic pulse duration t_{qbase} that is calculated at step S604 to provide corrected (final) pulse duration t_{qfin} . At step S608, basic pulse duration t_{qfin} is set into the driving pulse control register. The driving pulse is supplied to injector 1 to excite electromagnetic valve 1b during the corrected pulse duration to inject fuel.

[0067] As shown in Fig. 18, the fuel quantity to be corrected increases or decreases gradually as the command injection quantity increases. In other words, the inclination angle or the coefficient of a function of the command injection quantity relative to the injection pulse duration can be changed to fit to each injector 1.

[0068] Correction parameter TQC (j) can be obtained if first and second correction parameters TQC1 (j) and TQC2 (j) selected from correction parameter map 35A are multiplied by coefficient K that corresponds to the common-rail pressure P_C . As shown in Fig. 19, coefficient K is 1 where the common-rail pressure P_C is lower than a supplied fuel pressure (e.g. 60 MPa) at the time when correction parameters TQC1 (j) and TQC2 (j) are measured, and becomes smaller as the common-rail pressure P_C becomes higher as far as it is higher than the supplied fuel pressure.

(Third Embodiment)

[0069] A fuel injection system according to a third embodiment of the invention is described with reference to Figs. 20-27. In this system, a pilot injection for injecting a small quantity of fuel in advance of the main fuel injection is adopted. Electronic control unit 3B is substituted for the electronic control unit 3 of the fuel injection system according to the first embodiment. Electronic control system 3B is substantially the same in structure as the first embodiment except correction parameter map 35B.

[0070] In correction map 35B, a pair of correction parameters TQPC (j) and TQMC (j) corresponds to each voltage V_i , which is the detected resistance signal of correction resistor 2. The pair of correction parameters TQPC (j) and TQMC (j) is used for offset-correction of the injection pulse duration that is the valve opening period calculated from the command injection quantity. TQPC (j) is the pilot correction parameter of injection that is used when the command injection quantity of injector 1 is small, and TQMC (j) is the main correction parameter that is used when the command injection quantity of injector 1 is large.

[0071] In Fig. 22, an initial routine is started after IG key is turned on. At step S701, the RAM and other parts are initialized. At step S702, terminal voltage V_i of resistor 2 is read. At step S703, pilot correction parameter TQPC (j) and main correction parameter TQMC (j) for each cylinder are stored into a RAM. At step 703, if the voltage V_i is out of any one of the voltage grades, or if the pressure is lower than the pressure corresponding to the lowest voltage grade or higher than the pressure corresponding to the highest voltage grade, it is considered that a cable connecting injector 1 and electronic control unit 3 is short-circuited or cut. Consequently, pilot correction parameter TQPC (j) and main correction parameter TQMC (j) are set 0 μ s to stop the correction.

[0072] The pair of correction parameters TQPC (j) and TQMC (j) is selected only in the initial routine and will not be renewed until the IG key is turned on again. For example, the upper-and-lower-limit check routine is executed every 64 ms to prevent an erroneous storing in the RAM as described before. If it is considered as the erroneous storing in the RAM, pilot correction parameter TQPC (j) and main correction parameter TQMC (j) are set to 0.

[0073] Fig. 23 is an angular synchronism routine, which is executed every 180° CA in case of a four-cylinder engine. At step S801, operation parameters such as a throttle open angle A_c , a vehicle speed and the like are read. Then, command total injection quantity QFIN is calculated on the basis of the above operation parameters at step S802, and command pilot injection quantity QPLT is calculated at step S803. In step S804, command main injection quantity QMAIN is calculated from the following expression (3): $QMAIN = QFIN - QPLT$ (3)

[0074] At step S805, the common-rail pressure is read. At step S806, basic pilot injection period TQPLT and basic main injection period TQMAIN are obtained from command pilot injection quantity QPLT and command main injection quantity QMAIN and the common-rail pressure PC. At step S807, corrected injection pulse period TQPLTF, TQMAINF are calculated.

[0075] Fig. 24 shows details of step S807. At step S901, cylinder number (j) is read, and the corresponding correction parameters TQPC (j), TQMC (j) are read at step S902. At step S903, corrected injection pulse durations TQPLTF and TQMAINF are calculated by the following expression (4), wherein Tth is a threshold value.

$$TQPLTF = TQPLT + TQPC (j) \quad (4)$$

$$TQMAINF = TQMAIN + TQPC (j) \quad (QMAIN < Tth)$$

$$TQMAINF = TQMAIN + TQMC (j) \quad (QMAIN \geq Tth)$$

[0076] Thus, the correction parameters for injection pulse duration TQPLT and TQMAIN are separately set by small and large quantities

[0077] At step S808, target injection timings TPLT, TMAIN are calculated on the basis of the engine speed and the command total injection quantity. The injection timing is given as a crank angle, and a predetermined basic pulse of the crank angle signals corresponds to the basic angle to be measured. At step S809, corrected injection pulse durations TQPLTF and TQMAINF and command injection timings TPLT and TMAIN are set into the injection pulse control register. The corresponding injection pulses are supplied to injectors 1 to inject fuel.

[0078] Thus, each injector 1 is given a pair of correction parameters, one for small quantity and the other for large quantity. For example, if threshold value Tth is 10 mm³/st, pilot correction parameter TQPC = -10 μ s, and main correction parameter TQMC = +10 μ s, the result is shown in Fig. 25.

[0079] Fig. 26 is a graph showing relationship between the command injection quantity and the injection pulse duration before correction. There is a difference in shape between the pilot injection and the main injection. In the pilot injection, needle valve 106 is not fully lifted and the fuel flow is controlled by the throttle of the seat. In the main injection range, it is fully lifted so that the fuel flow is controlled by fuel injection hole 102. Therefore, correction parameter should be different between the pilot injection range and the main injection range. As shown in Fig. 27, the offset correction in

the pilot injection range is made differently from that in the main injection range so that accurate correction for each injector can be carried out.

(Fourth Embodiment)

[0080] A fourth embodiment of the invention is described with reference to Figs. 28-38. As shown in Fig. 28, a correction parameter or a fragment ΔT is added to or subtracted from the basic pulse duration calculated from the command injection quantity to make the injection pulse duration shorter, so that the injection rate is compressed time-wise from ① to ②. Consequently, the injection rate of the respective injectors does not change even if the injection characteristic of injectors 1 is different from each other. In this embodiment, the injection timing is corrected one by one as indicated by ③. As a result, a simple structure having a desirable combustion characteristic can be provided.

[0081] As shown in Fig. 29, electronic control unit 3C is only different from the electronic control unit 3 of the first embodiment in that electronic control unit 3C has correction parameter map 35C.

[0082] Correction parameter map 35C, as shown in Fig. 30, has a pair of correction parameters TQPC' (j) and TQMC' (j) corresponds to each voltage V_i . The pair of correction parameters TQPC' (j) and TQMC' (j) is for offset-correction of the injection pulse duration that corresponds to the valve opening period calculated on the basis of the command injection quantity. Correction parameters TQPC' (j) is a correction parameter for the small-fuel-quantity pilot injection, and TQMC' (j) is a correction parameter for the large-fuel-quantity main injection. The pair of pilot injection correction parameters TQPC' (j) and main injection correction TQMC' (j) is used to correct the basic pulse duration calculated from the command injection quantity as in the third embodiment. Electronic control unit 3C has basic injection delay time map 37 and injection-delay adjusting-coefficient map 38, which are stored in ROM 310 together with correction parameter map 35C.

[0083] Fig. 31 is a table showing the content of basic injection delay time map 37, in which the basic injection delay time TD corresponds to the common-rail pressure PC. Fig. 32 is a table showing the content of injection-delay adjusting-coefficient map 38, in which the injection delay adjusting coefficient Kpc corresponds to the common-rail pressure PC.

[0084] In Fig. 33, the initial routine is executed after the IG key is turned on. An step S1001, the RAM and other parts are initialized. At step S1002, terminal voltage V_i of resistor 2, which is built in connector 1c of each injector 1, is read. At step S1003, pilot correction parameter TQPC' (j) and main correction parameter TQMC' (j) for each cylinder are stored into a RAM. At step 1003, if the voltage V_i is out of any one of the voltage grades, or if the pressure is lower than the pressure corresponding to the highest voltage grade, it is considered that a cable connecting injector 1 and electronic control unit 3 is short-circuited or cut. Consequently, pilot correction parameter TQPC (j) and main correction parameter TQMC (j) are set 0 μ s.

[0085] The pair of correction parameters TQPC (j) and TQMC (j) is selected only in the initial routine, and will not be renewed until the IG key is turned on again. Therefore, the upper-and-lower-limit check routine is executed every 64 ms to prevent an erroneous storing in the RAM. If it is considered as the erroneous storing in the RAM, pilot correction parameter TQPC' (j) and main correction parameter TQMC' (j) are set to 0.

[0086] Fig. 34 is an angular synchronism routine, which is executed every 180° CA in case of a four-cylinder engine. At step S1101, operation parameters such as a throttle open angle A_c , a vehicle speed and the like are read. Then, command total injection quantity QFIN is calculated on the basis of the above operation parameters at step S1102, and command pilot injection quantity QPLT is calculated at step S1103. In step S1104, command main injection quantity QMAIN is calculated from the following expression (5):

$$QMAIN = QFIN - QPLT \quad (5)$$

[0087] At step S1105, the common-rail pressure is read. At step S1106, basic pilot injection period TQPLT and basic main injection period QMAIN are obtained from command pilot injection quantity QPLT and command main injection quantity QMAIN respectively calculated at steps S1103 and S1104 and the common-rail pressure PC. At step S1107, corrected injection pulse period TQPLTF, TQMAINF are calculated.

[0088] Fig. 35 shows details of step S1107. At step S1201, cylinder number (j) is read, and the corresponding correction parameters TQPC' (j), TQMC' (j) are read at step S1202. At step S1203, corrected injection pulse durations TQPLTF and TQMAINF are calculated by the following expression (6).

$$TQPLTF = TQPLT + TQMC' (j) + TQPC' (j) \quad (6)$$

$$TQMAINF = TQMAIN + TQMC' (j)$$

$$TQMAINF = TQMAIN + TQMC' (j)$$

[0089] At step S1108, target injection timings TPLT, TMAIN are calculated on the basis of the engine speed Ne and the command total injection quantity QFIN. The injection timing is given as a crank angle, and a predetermined basic pulse of the crank angle signals corresponds to the basic angle to be measured. At step S1109, the basic injection delay time TD that corresponds to the common-rail pressure is calculated according to basic injection delay time map 37. At the next step S1110, injection delay time correction parameter TDP (j), TDM (j) are calculated. Fig. 36 shows details of step S1110, where the cylinder number is read at first at step S1301, and the corresponding correction parameters TQPC' (j) and TQMC' (j) are read at step S 1302. At step S1303, injection delay time correction parameters TDP (j) and TDM (j) are calculated by expression (7). In the expression, Kpc is read from injection-delay adjusting-coefficient map 38.

$$TDP(j) = Kpc \times (TQMC'(j) + TQPC'(j)) \quad (7)$$

$$TDM(j) = Kpc \times TQMC'(j)$$

[0090] At the next step S1111, the injection delay time TD of the pilot injection and the main injection is corrected by the injection delay time TDP and TDM (j), which are converted into the crank angle.

$$TPLTC(j) = 6 \times Ne \times (TD + TDP(j)) \times 10^{-6} \quad (8)$$

$$TMAINC(j) = 6 \times Ne \times (TD + TDM(j)) \times 10^{-6}$$

[0091] At the next step S1112, final command injection timings TPLTF and TMAINF are calculated by expression (9) from target command injection timings TPLT and TMAIN calculated at step S1108 and injection delay time correction angles TPLTC (j) and TMAINC (j) calculated at step S1111.

$$TPLTF = TPLT - TPLTC(j) \quad (9)$$

$$TMAINF = TMAIN - TMAINC(j)$$

[0092] At step S1113, corrected injection pulse durations TQPLTF and TQMAINF and corrected command injection timings TPLTF and TMAINf are set into the injection pulse control register. The corresponding injection pulses are supplied to injectors 1 to inject fuel.

[0093] In expression (7) of the above control flow diagram, the injection delay time correction parameters TDP (j) and TDM (j) are connected by the adjusting coefficient Kpc with the injection delay time correction parameters TQPC' (j) and TQMC' (j) and can be easily calculated.

[0094] It has been observed that the delay time of the injectors responsive to the injection pulses is a main factor of the variation in the injection quantity of the injectors. The deviation of the correction value ΔT for correcting the injection quantity and injection delay time Δt were also examined. Fig. 37 show the result, in which there is correlation between the correction value ΔT and the injection delay time Δt . The correlation can be expressed by a correlation function having the coefficient Kpc that is one of the adjusting coefficient. Accordingly, the injection delay time correction parameter TDP (j) and TDM (j) can be obtained by a simple calculation from expression (7). Thus, the injection quantity of the main injection is corrected by TQMC (j), and the injection quantity of the pilot injection is corrected by (TQCMC' (j) + TQPC' (j)). The injection delay times, TDP (j) and TDM (j), can be obtained by multiplying the above by the adjusting coefficient Kpc.

[0095] As shown in Fig. 38, the pilot injection and the main injection are outputted so that the injection pulses can offset the deviations in the injection delay time and the injection quantity of the respective injectors. As a result, accurate fuel injection quantity can be supplied at proper timings.

[0096] As a result, a plurality of correction parameters are selected by the terminal voltage of the built-in correction resistor of the injector from the correction parameter map to offset deviations between the injectors. However, a single correction of the injection pulse duration and the injection delay time can represent each of the injectors if the deviations to be offset among the injectors are permitted to a certain amount. For example, the injection pulse duration is offset over the entire command quantity range by a constant value. The correction parameters can be adjusted according to the common-rail pressure.

(Fifth Embodiment]

[0097] In the above embodiment, the injectors have a built-in resistor to use its resistance as a discrimination signal. The electronic control unit only has to measure the terminal voltage of the built-in resistor to obtain the discrimina-

tion signal from the resistor. If a limited number of vehicles are manufactured, the production cost may not be reduced sufficiently due to the design change of the electronic control unit and the injectors. According to the invention, it is not necessary to change the design of the wiring which connect the injectors and the electronic control unit.

[0098] Figs. 39 and 40 illustrate the injector and a fuel injection system according to the fifth embodiment of the invention. Injector 1A is substantially the same as those of the precedent embodiments except that connectors 1d do not have the correction resistors and their terminals. Instead of the correction resistor, injectors 1A have a data-memory-tag 2A which has bar codes 21 thereon and is stuck to the surface thereof. The information of bar codes 21 fixed to one of the injectors 1A represent the injection characteristic of the one injector. Such information includes, for example, high-side correction parameter tqcmh (j) and low-side correction parameter tqcml (j) of the first embodiment. The bar codes are read by bar code reader 91 before the injectors are lined off an assembling line. The read data of the correction parameters are stored into an address of ROM 310 of electronic control unit 3D, which corresponds to the cylinder number to which the injector is to be fixed, by ROM writer 92. ROM 310 is a EEPROM which is writable.

[0099] Electronic control unit 3D corrects the injection timing on the basis of the written correction parameters. Because the correction parameters are memorized as bar codes 21, it is not necessary to have a correction map to link bar code data to the correction parameters. It is also possible to provide bar codes which include only the data discriminating kinds of the injection characteristic. The electronic control unit has a correction parameter map, and some correction parameters are selected according to the data of the bar codes. Instead, as shown in Fig. 41, data base 93 that correspond to the correction parameters may be provided, and the correction parameters that correspond to the bar codes read by bar code reader 91 are selected and sent to ROM writer 92.

[0100] Data memory for the injector discriminating data is not limited to the above correction resistors or tags having bar codes thereon. For example, the electronic control unit has a correction parameter map and a DIP switch for memorizing injector's injection characteristic data. Injector has a tag fixed thereto which prescribes setting of the DIP switch. The DIP switch is set before the injection system is lined off as the fifth embodiment.

[0101] Deviation in fuel injection quantity among injectors (1) is corrected by a simple structure. Injector 1 is provided with data memory (2, 2A) which memorizes discrimination data for injection characteristic of each of the injectors (1) to discriminate the injection characteristic of individual injectors (1). As a result, control signals supplied to the injector 1 are corrected to reduce deviation in the fuel injection quantity among the injectors (1) without much increasing production cost and to save work of allocating each of the injectors (1) 1 to a specified cylinder.

Claims

1. An injector controlled by a control signal, wherein a data memory (2, 2A) for storing discrimination data of respective injection characteristics of said injector (1) is provided to correct said control signal on the basis of said discrimination data.

2. The injector according to claim 1, wherein said data memory (2, 2A) comprises a resistor (2) having a resistance as said discrimination data.

3. The injector according to claim 1, wherein said data memory (2, 2A) is a tag (2A) on which bar-codes are formed as said discrimination data.

4. An injection system including said injector (1) claimed in any one of claims 1-3 and control means (3, 3A, 3B, 3C, 3D) which calculates valve opening period on the basis of command injection timing and command injection quantity to provide control signal corresponding to said valve opening period, wherein

said control means (3, 3A, 3B, 3C) includes a correction parameter map (35, 35A, 35B, 35C) in which correction parameters respectively correspond to said discrimination data, and one of said correction parameters is selected from said data memory (2, 2A) to correct said valve opening period.

5. The fuel injection system according to claim 4, wherein said data memory (2, 2A) comprises said resistor (2), and

said control means (3, 3A, 3B, 3C, 3D) comprises resistance measuring means (3a) for measuring the resistance of said resistor (2) as said discrimination data.

6. The fuel injection system according to claim 4 or 5, wherein said correction parameter map (35, 35A, 35B, 35C) has a plurality of correction parameters that correspond to one of said discrimination data.

7. The fuel injection system according to any one of claims 4-6, wherein

each of said correction parameters includes an offset value of said valve opening period at a basic pressure of supplied fuel,

said control means (3, 3A, 3B, 3C) includes a valve-opening-adjusting-coefficient map (36) having a plurality of valve-opening-period-adjusting coefficients in accordance with the pressure of supplied fuel, and
 5 an offset value of a valve opening period is obtained by multiplying one of said valve-opening-period-adjusting coefficients by said offset value at said basic pressure.

8. The fuel injection system according to claim 7, wherein

10 each of said correction parameters includes a low-side offset value of valve opening period at a lower side basic pressure of the supplied fuel and a high-side offset value of valve opening period at a higher side basic pressure of the supplied fuel,

an offset value of valve opening period at a low-side actual fuel pressure is obtained by multiplying one of said valve-opening-period-adjusting coefficients selected from the valve-opening adjusting-coefficient map by said
 15 low-side offset value, and

said offset value of valve opening period at a high-side actual fuel pressure is obtained by multiplying one of said valve-opening-period-adjusting coefficients selected from the valve-opening adjusting-coefficient map by said high-side offset value.

20 9. The fuel injection system according to any one of claims 4-8, wherein

each of said correction parameters includes an offset value of valve opening period, and
 said offset value of valve opening timing is obtained by multiplying a corresponding one of valve-timing-adjusting coefficients by said offset value of valve timing.

25 10. The fuel injection system according to claim 7 or 8, wherein

said control means (3, 3A, 3B, 3C) includes a valve-timing-adjusting-coefficient map having a plurality of valve-timing-adjusting-coefficients in accordance with the pressure of the supplied fuel, and

30 an offset value of actual valve timing is obtained by multiplying said offset value of valve opening period at said basic pressure by one of valve-timing-adjusting coefficients selected from said valve-timing-adjusting-coefficients map.

35 11. The fuel injection system according to any one of claims 4-10, wherein each of said correction parameters includes the same kind of correction parameters in accordance with the command-injection-quantity.

12. The fuel injection system according to any one of claims 4-10, wherein

40 each of said correction parameters includes an offset value of valve opening period when said command injection quantity is a small basic injection quantity in a smaller quantity side and an offset value of valve opening period when said command injection quantity is in a large basic injection quantity of a larger quantity side, and said valve opening period is obtained by linear interpolation of two valve opening periods that are respectively corrected in said two basic injection quantities.

FIG. 1

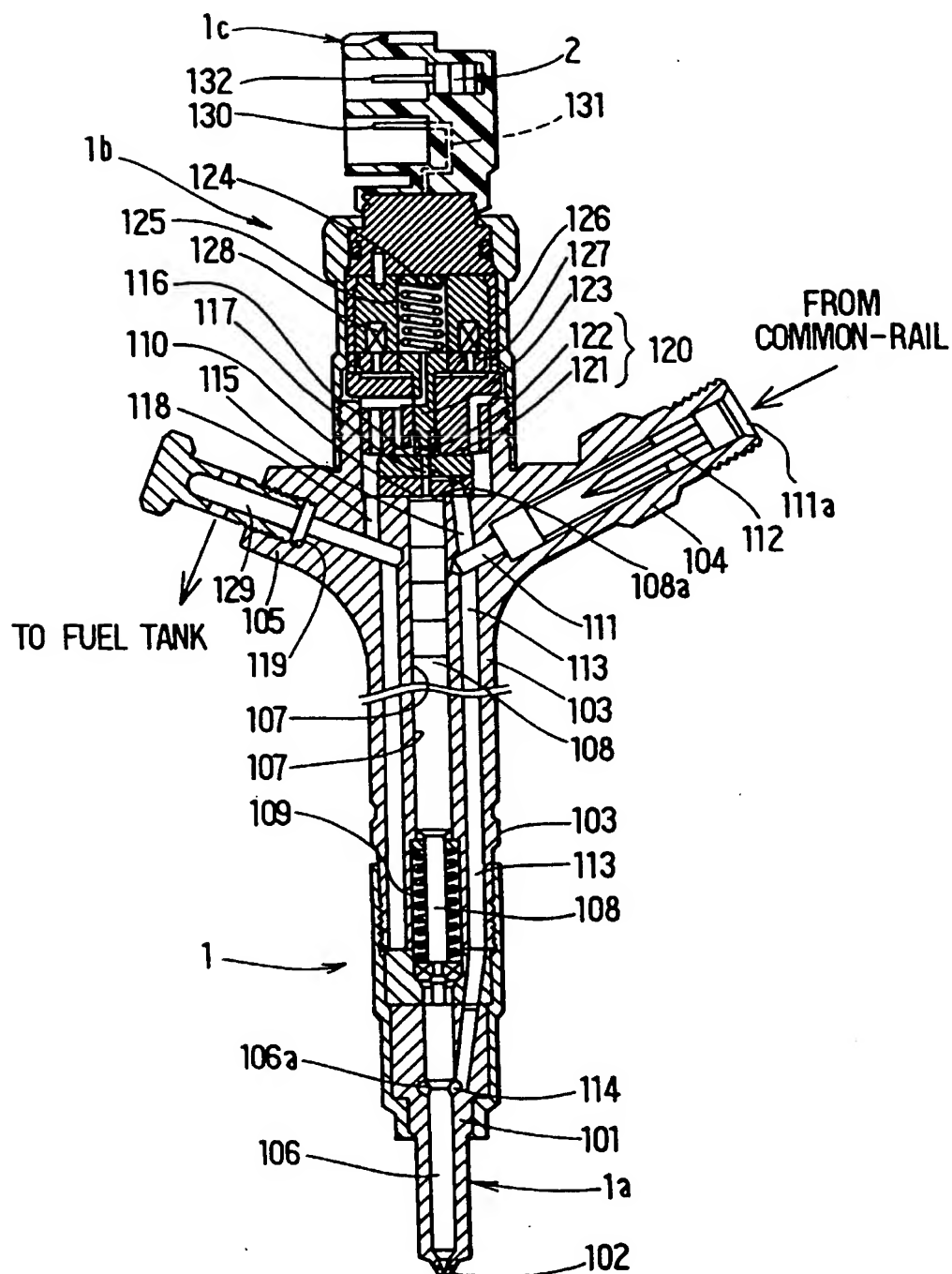


FIG. 2

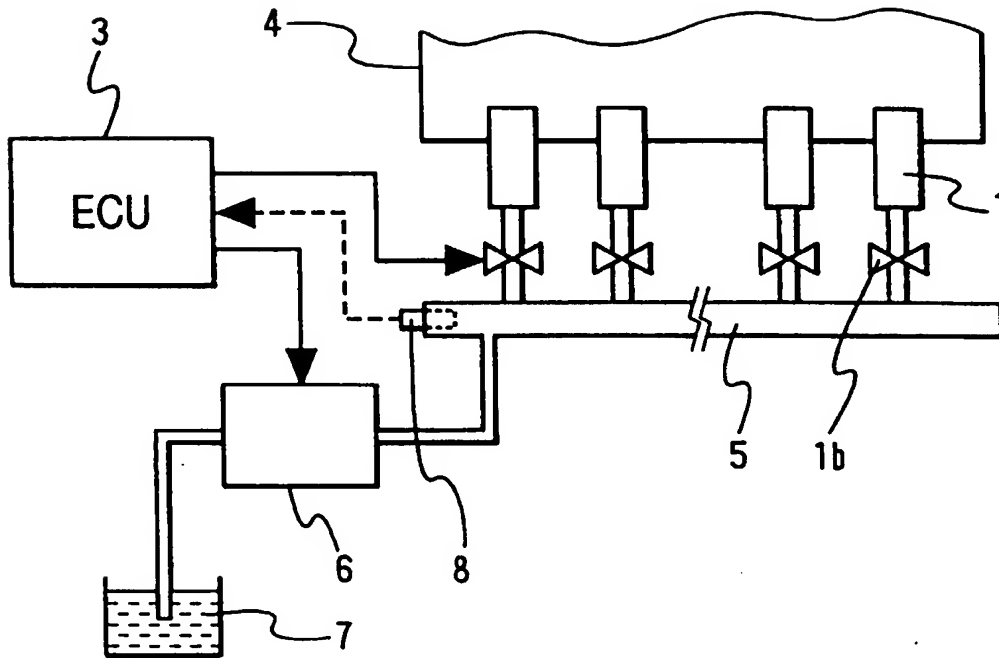


FIG. 3

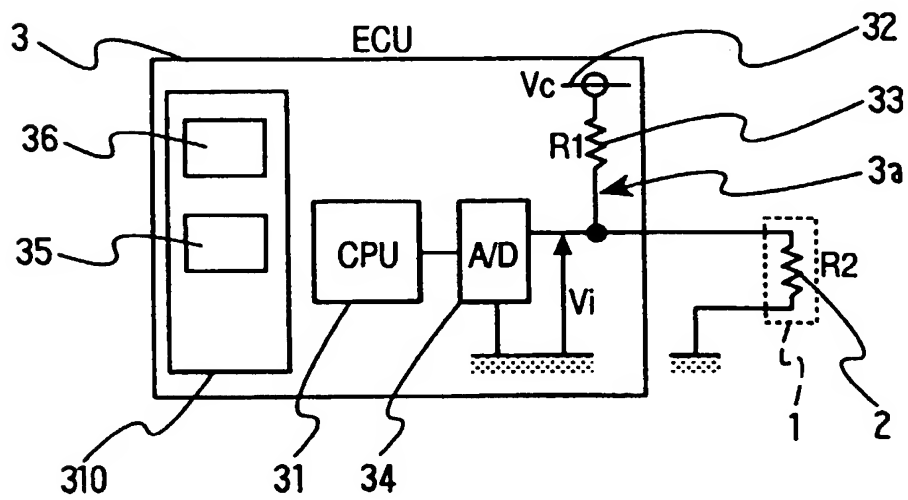


FIG. 4

t_{qcmI}

$-50\mu s \quad -25\mu s \quad \pm 0\mu s \quad +25\mu s \quad +50\mu s$

$-40\mu s$	1	2	3	4	5
$-20\mu s$	10	9	8	7	6
$\pm 0\mu s$	11	12	13	14	15
$+20\mu s$	20	19	18	17	16
$+40\mu s$	21	22	23	24	25

t_{qcmh}

FIG. 5

No.	Ω	No.	Ω	No.	Ω	No.	Ω	No.	Ω
1	37.4	6	178	11	392	16	768	21	1580
2	60.4	7	210	12	453	17	866	22	1870
3	86.6	8	249	13	511	18	1000	23	2260
4	115	9	294	14	590	19	1150	24	2740
5	143	10	340	15	665	20	1330	25	3480

FIG. 6

PC(MPa)	25	32	48	64	80	135
t_{mtqpch}	0	0	0	0.541	0.713	1
t_{mtqpcl}	0.916	1.306	1	0	0	0

FIG. 7

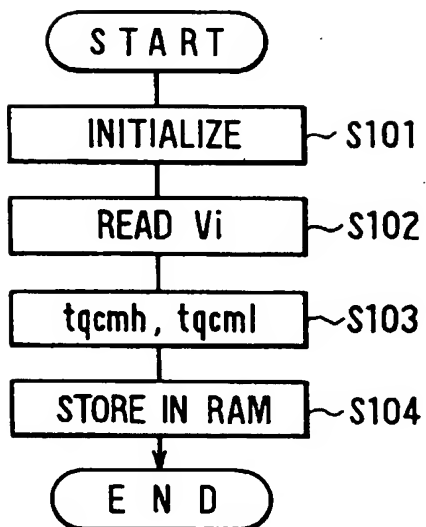


FIG. 8

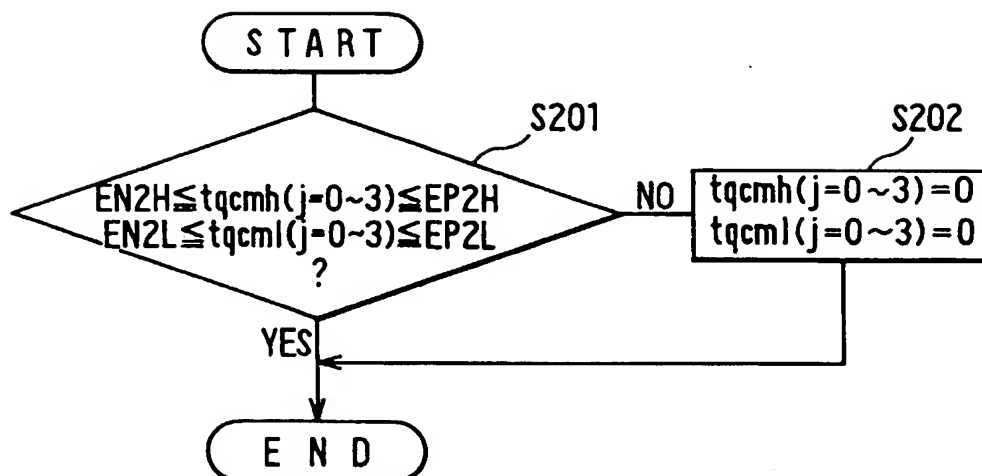


FIG. 9

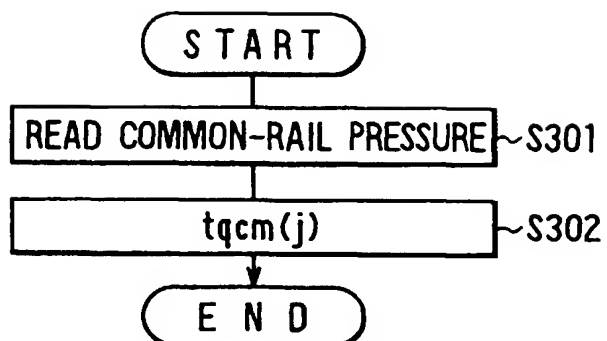


FIG. 10

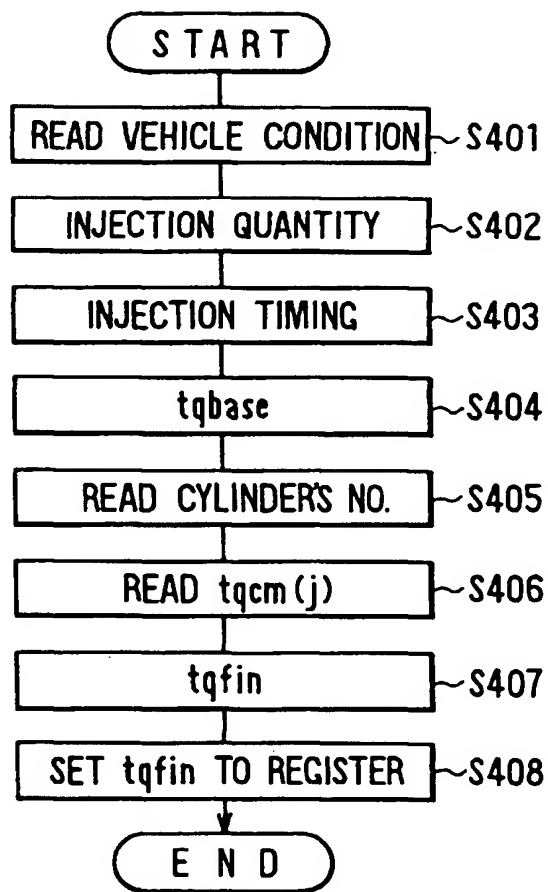


FIG. 11

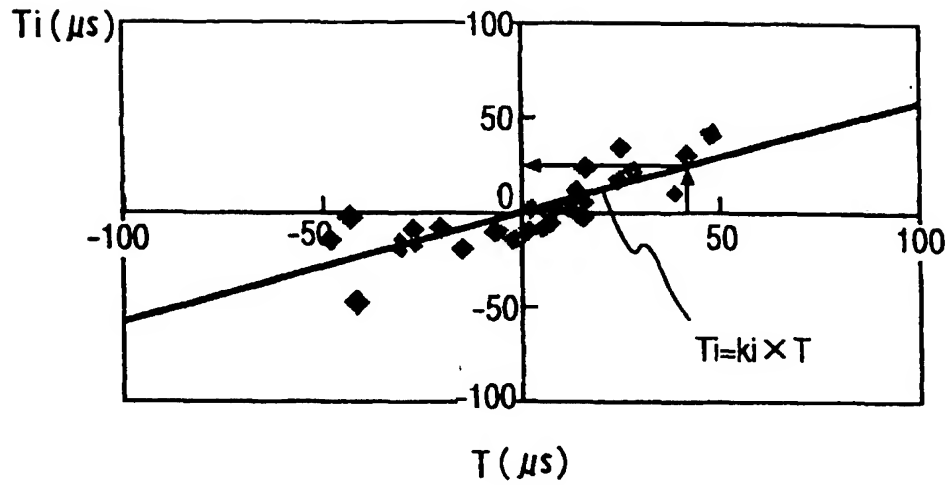


FIG. 12

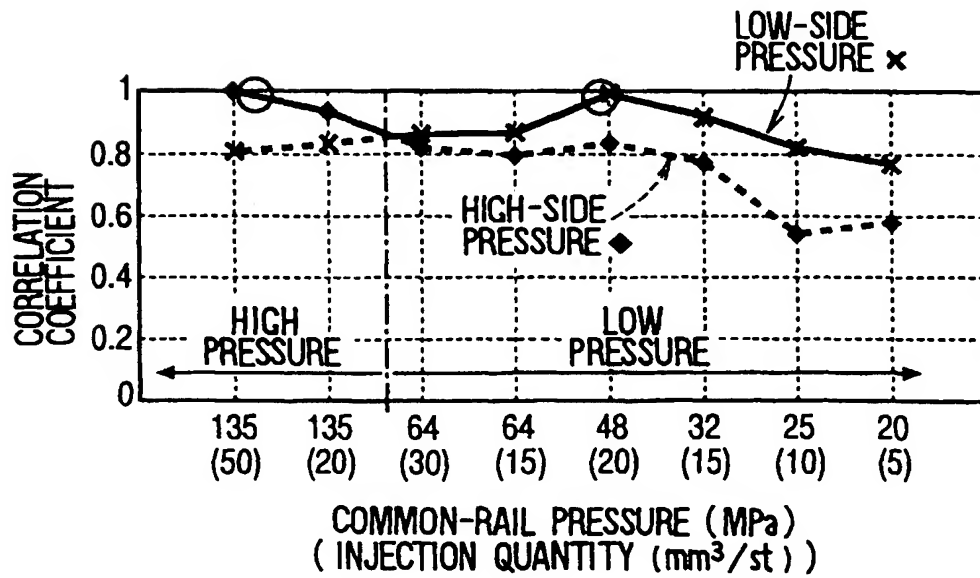


FIG. 13

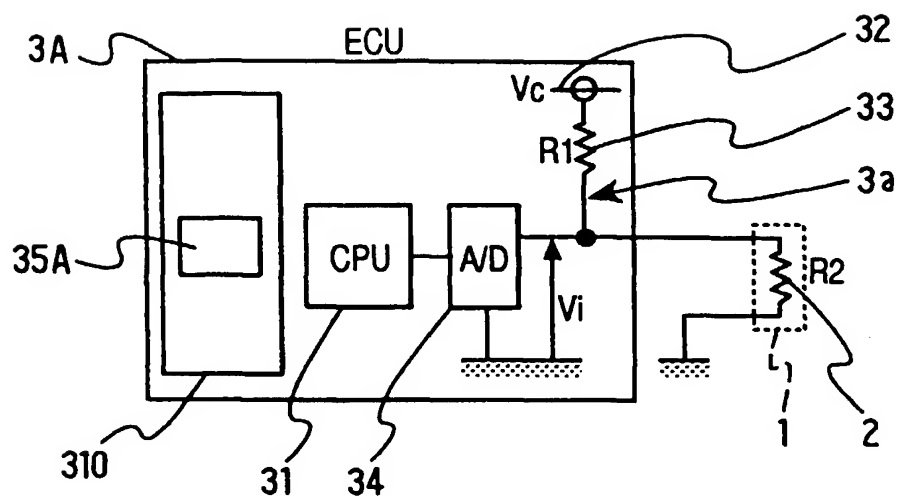


FIG. 14

TQC2
($Q=5\text{mm}^3/\text{st}$)

$-20\mu\text{s} \quad -10\mu\text{s} \quad \pm 0\mu\text{s} \quad +10\mu\text{s} \quad +20\mu\text{s}$

$-20\mu\text{s}$	1	2	3	4	5
$-10\mu\text{s}$	10	9	8	7	6
$\pm 0\mu\text{s}$	11	12	13	14	15
$+10\mu\text{s}$	20	19	18	17	16
$+20\mu\text{s}$	21	22	23	24	25

TQC1
($Q=50\text{mm}^3/\text{st}$)

FIG. 15

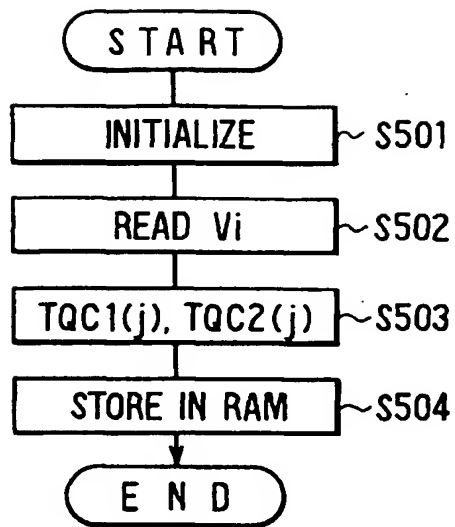


FIG. 16

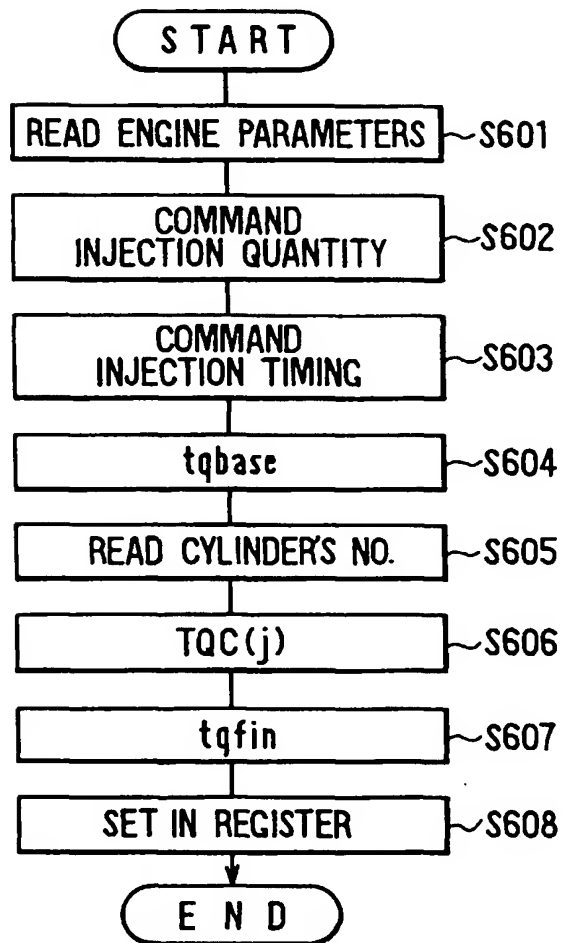


FIG. 17

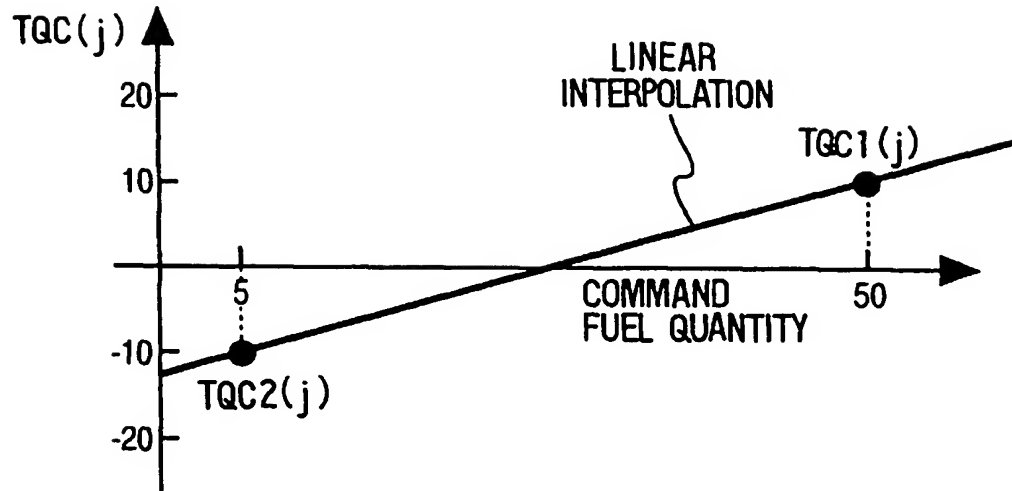


FIG. 18

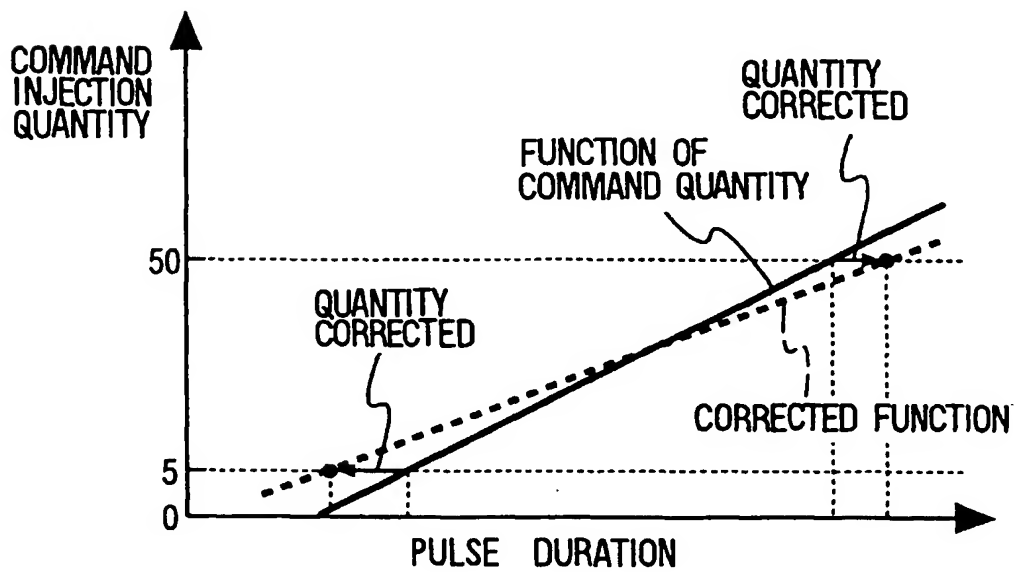


FIG. 19

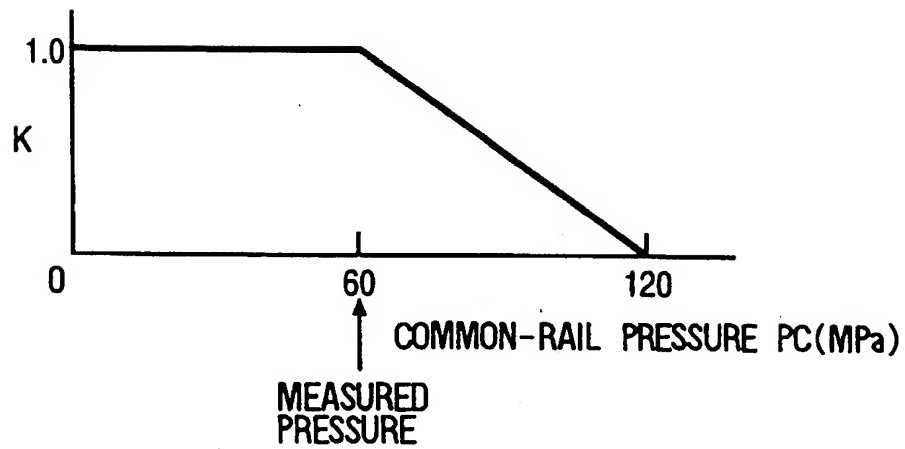


FIG. 20

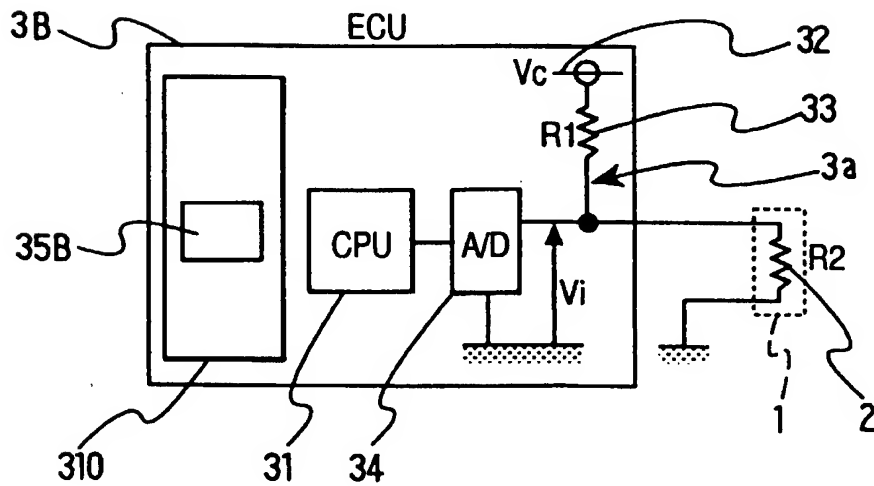


FIG. 21

TQMC

		$-20\mu s$	$-10\mu s$	$\pm 0\mu s$	$+10\mu s$	$+20\mu s$
	$-20\mu s$	1	2	3	4	5
	$-10\mu s$	10	9	8	7	6
TQPC	$\pm 0\mu s$	11	12	13	14	15
	$+10\mu s$	20	19	18	17	16
	$+20\mu s$	21	22	23	24	25

FIG. 22

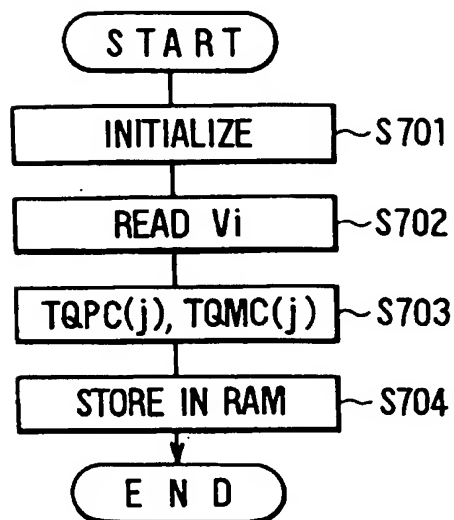


FIG. 23

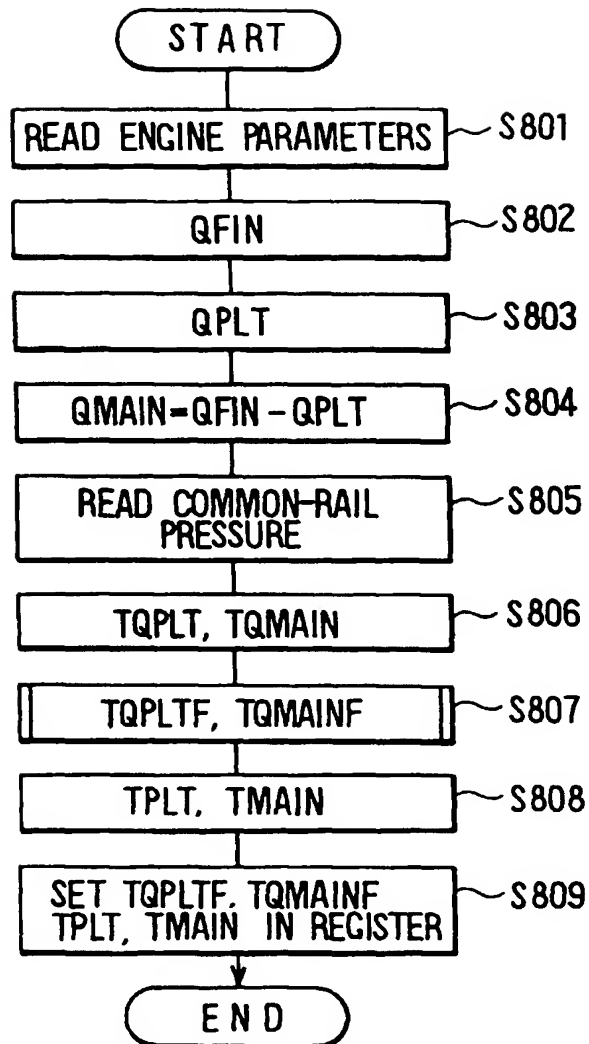


FIG. 24

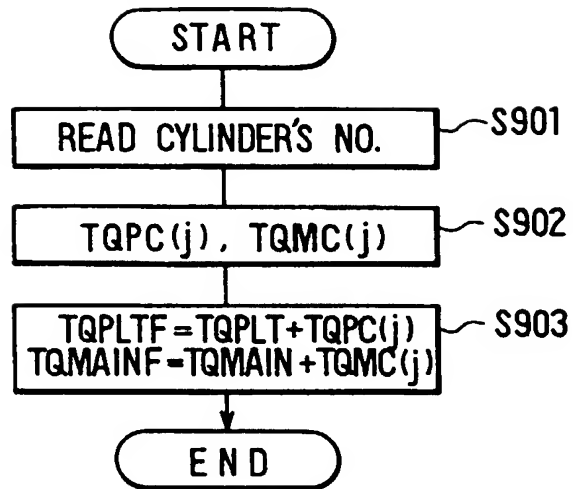


FIG. 25

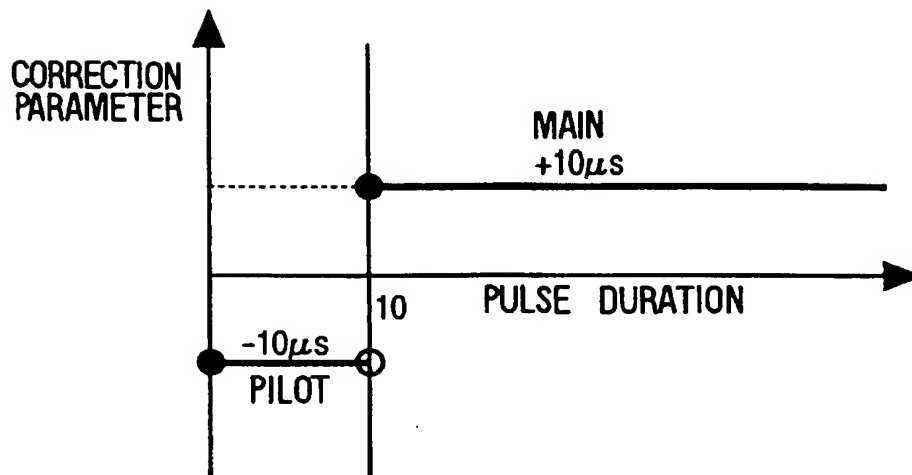


FIG. 26

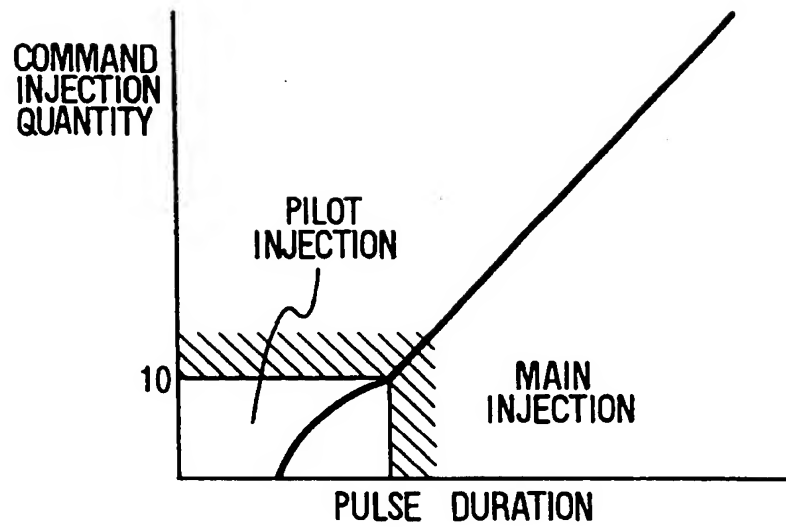


FIG. 27

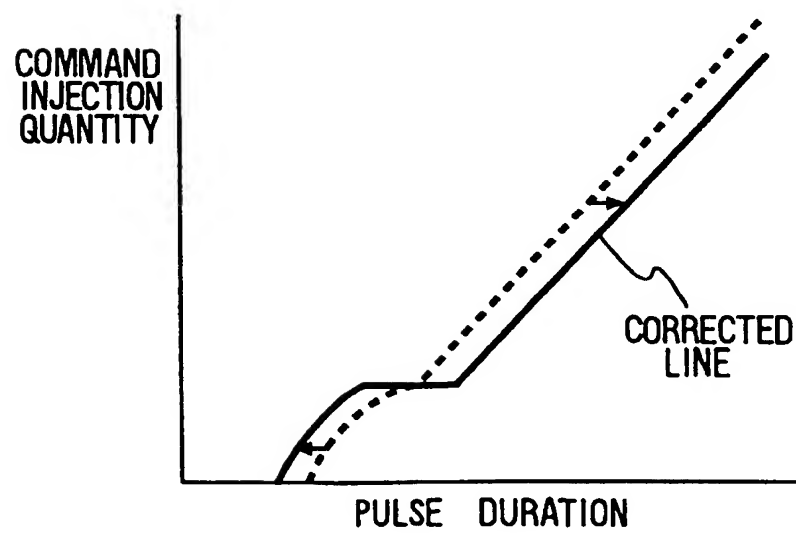


FIG. 28

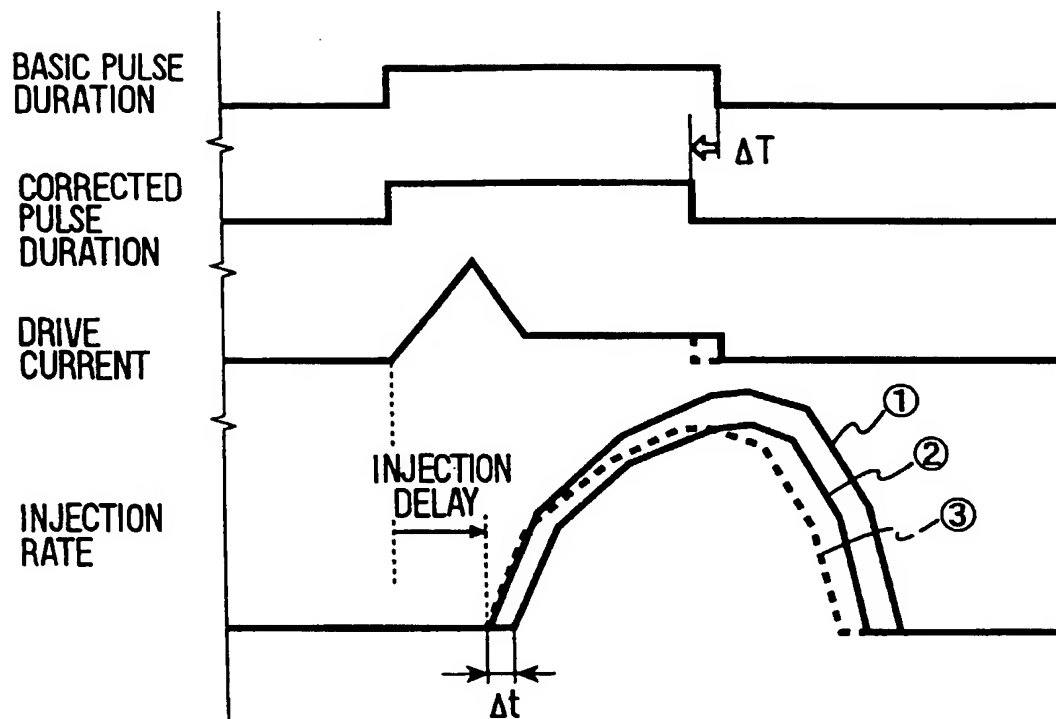


FIG. 29

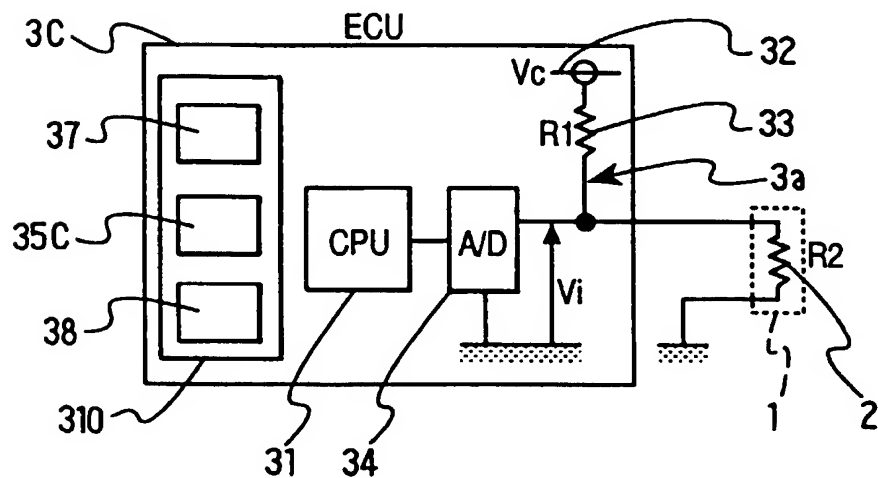


FIG. 30

TQPC'

TQMC'

	$-20\mu s$	$-10\mu s$	$\pm 0\mu s$	$+10\mu s$	$+20\mu s$
$-20\mu s$	1	2	3	4	5
$-10\mu s$	10	9	8	7	6
$\pm 0\mu s$	11	12	13	14	15
$+10\mu s$	20	19	18	17	16
$+20\mu s$	21	22	23	24	25

FIG. 31

PC(MPa)	20	32	48	64	80	135
TD(μs)	635	635	630	620	650	730

FIG. 32

PC(MPa)	20	32	48	64	80	135
Kpc	0.2	0.22	0.31	0.33	0.45	0.5

FIG. 33

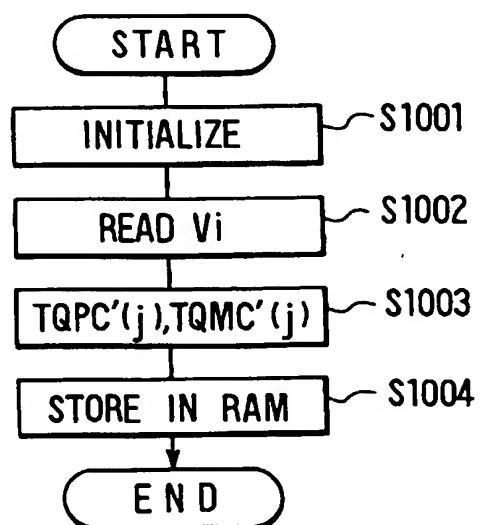


FIG. 34

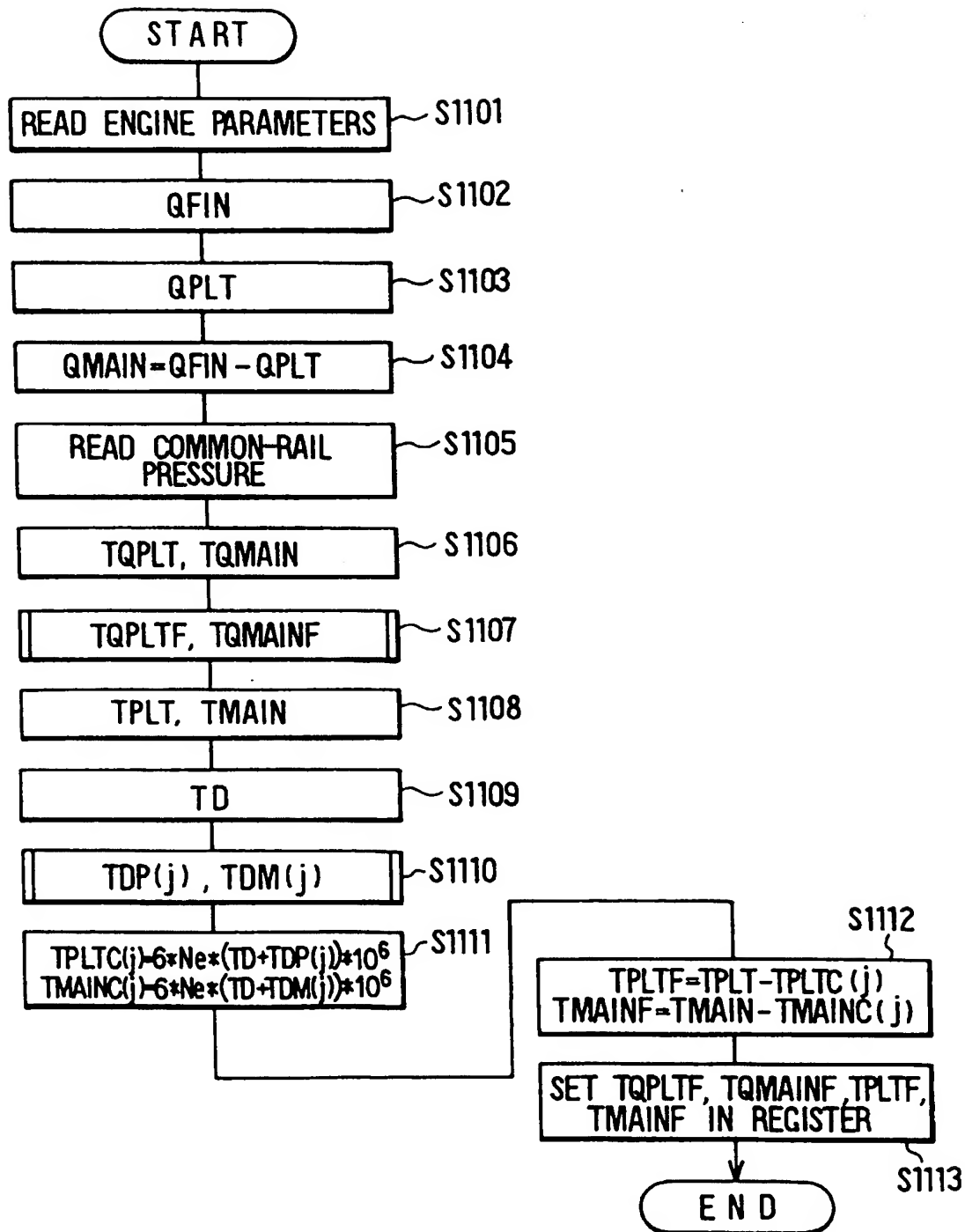


FIG. 35

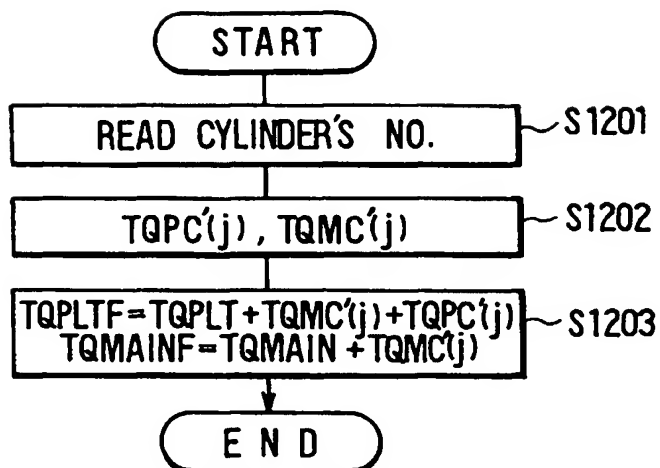


FIG. 36

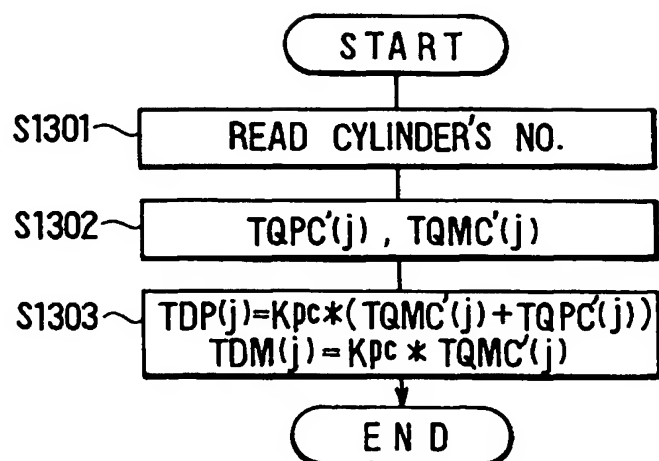


FIG. 37

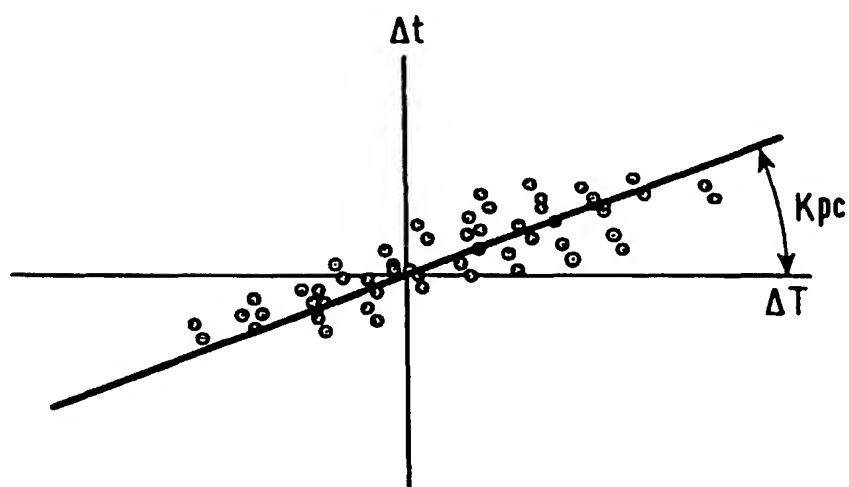


FIG. 38

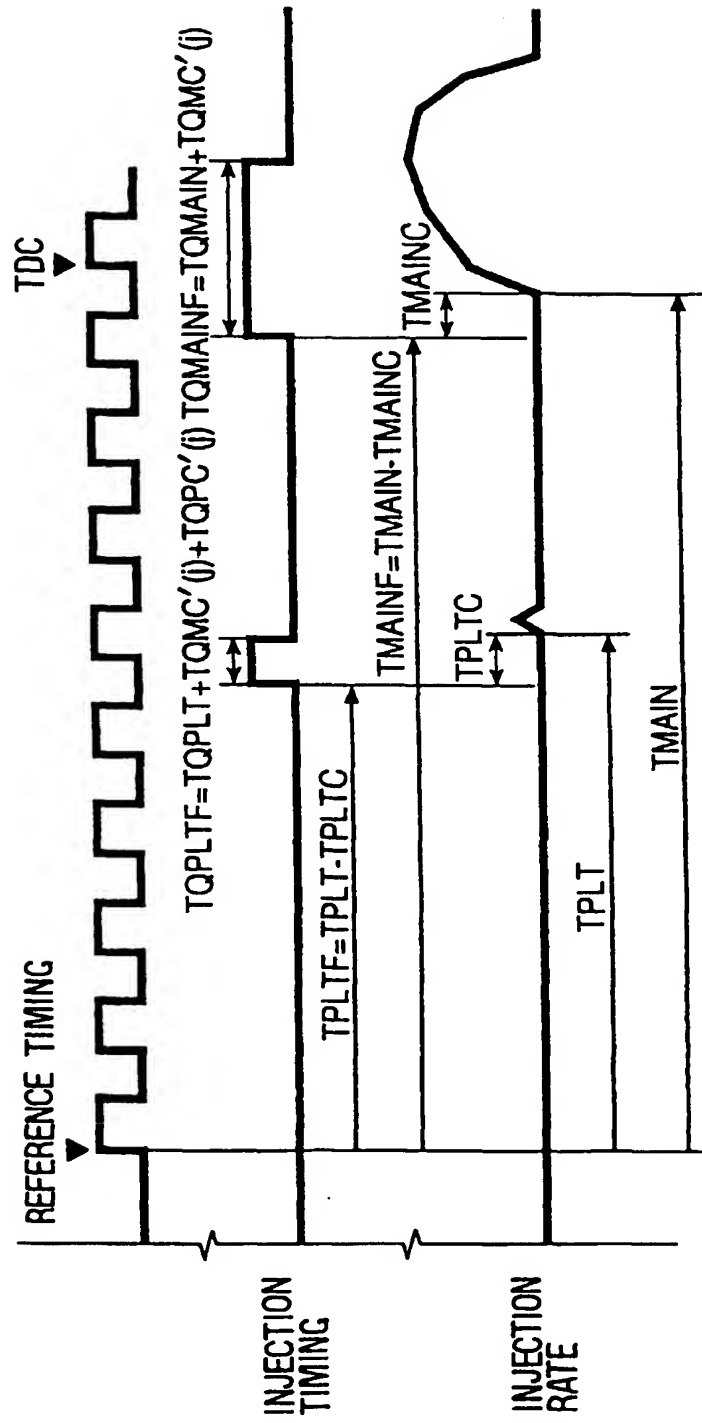


FIG. 39

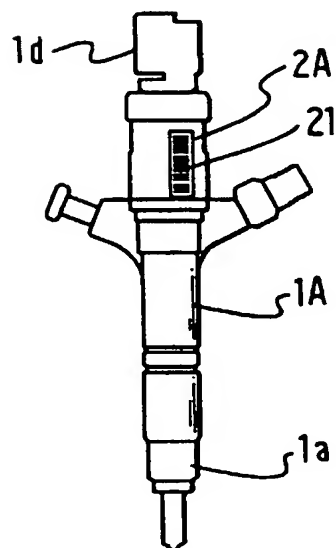
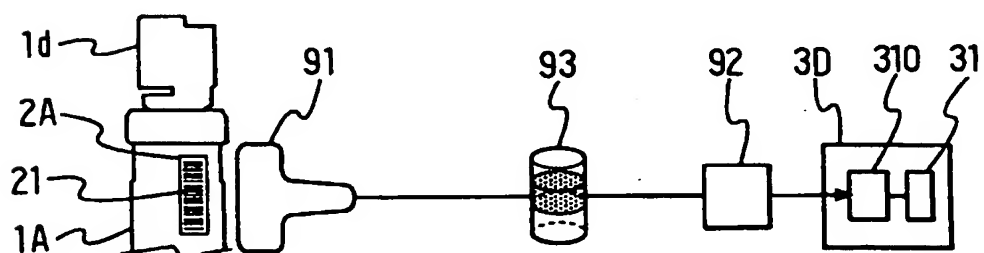


FIG. 40



FIG. 41





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 10 1856

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